HOM Evaluation Status
10/10/00
Ron Sundelin

- **Principal Participants**
  - **Sang-ho Kim**
  - **Dong-o Jeon**
  - **Marc Doleans**
  - **Jacek Sekutowicz**

- **Determination of mode properties**
  - **Jacek determined R/Q of 0, 1 pole modes, beta 0.61**
  - **Sang-ho determined R/Q of 0, 1, 2, 3 pole modes, betas 0.61, 0.81**
    - **Including relative energies in each end cell**
      - **Looks for trapped modes**
    - **Analyzing effects of mechanical deviations from nominal**
      - **Can trap nominally untrapped modes**

- **Relationship between actual cavity properties and calculated properties**
  - **Frequency spreads reduce beam dynamics problems**
  - **Lowest frequency spread on stamped cup, beam welded cavities**
    - **Provides most conservative estimate**
    - **Result from Cornell study with tuned fundamental mode**
      - $\sigma = 0.00109 * |f - f_o|$

- Differences between measured centroids and calculations
  - Important for determining whether or not mode can land on beam spectral line
  - HOMs
    - ± 0.00376 maximum fractional error from Cornell study
    - Use ± 0.008 maximum for SNS in case error is larger
  - Other fundamental passband modes
    - $\left| ((f_{meas} - f_{calc})/(f_{calc})) / ((f_{pi} - f_{mode})/(f_{pi})) \right| \leq 0.027$
      - From Cornell study
    - Use 2.5 X this for SNS in case error is larger

- Beam interactions with cavity - four important cases
  - Transverse, not on major beam spectral line
    - Existence of potential instability at an arbitrary HOM frequency confirmed, quasi-exponential growth
      - Selected highest R/Q transverse mode
      - With no frequency spread, required Q $\leq$ 8.64 * 10**5
      - With 0.2 X expected frequency spread, required Q $\leq$ 1.27 * 10**9
        - Lowest Q found with 80 Monte Carlo seeds
    - All identified beta = 0.61 modes have been explored
      - No instabilities with Q $\leq$ 10**8, 0.2 X expected frequency spread
    - Beta = 0.81 modes remain to be explored
  - Transverse, near major beam spectral line
    - Case previously evaluated by Jeon
    - Results in time-dependent magnification of beam steering error
      - Frequency spreads and reduced Qs lower magnification
    - All identified beta = 0.61 modes have been explored
      - No measurable magnifications with Q $\leq$ 10**8, 0.2 X expected

frequency spread
  - Beta = 0.81 modes remain to be explored
- Longitudinal, not on major beam spectral line
  - Existence of potential instability at an arbitrary HOM frequency confirmed, quasi-exponential growth
    - Growth more limited than transverse case because of non-linear relativistic effects
      - Simulation uses linearized RF restoring force
  - All identified beta = 0.61 modes have been partially explored
    - No instabilities with Q $\leq$ 10**6, 0.2 X expected frequency spread
  - Beta = 0.81 modes remain to be explored
- Longitudinal, near major beam spectral line
  - Case being evaluated by Sang-ho, Ron
  - Results in time-dependent beam energy and timing error
    - Frequency spreads and reduced Qs reduce effect
  - Can result in substantial production of HOM power (related to first effect)
    - Frequency spreads can reduce likelihood of hitting beam spectral line
    - Simulation returns cavity with smallest number of standard deviations from nominal frequency to nominal frequency
    - Reduced Qs can lower amount of power produced
    - This effect will require the use of HOM couplers
  - Initial investigation of all beta = 0.61 cavities has been performed
    - Q = 10**6 for all modes
    - Modes 31, 32, and 36 can produce substantial HOM power
      - These modes are “snapped” to microbunch harmonic
      - Other HOMs are “snapped” to notch harmonic

- Inconvenient but manageable
- Q = expected values for fundamental passband modes
- 5 π / 6 mode presents a major problem
  - This mode is snapped to a 60 Hz harmonic, not a notch harmonic
  - Large energy error growth
  - Substantial total amount of HOM power generated
  - Appears to be driven by general proximity to a beam harmonic
    - Possibly compounded by general proximity to notch harmonic
  - Not controlled by 0.2 X expected frequency spread
  - How should this be addressed?
    - Finish checking simulation code for errors
      - Continue using simulation code to understand cause and possible cures
    - Feedback via main klystron (bandwidth sufficient?)?
    - Preferential extraction of this mode?